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During the past several years there has been growing interest in developing ultra wideband RF systems. The wide variety of possible usages for such systems include countermeasures, electronic intelligence gathering, and target detection and identification. In these systems, one of the key elements is the antenna which allows the energy to be radiated and collects the return signal. Various approaches including cavity backed spirals, sinuous antennas, and ridged horns have been considered to achieve broad bandwidth. This paper describes a novel technique for designing an ultra wideband antenna by proposing a new TEM-type feed.

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AN ULTRA-WIDEBAND REFLECTOR ANTENNA

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Introduction

During the past several years there has been growing interest in developing ultra wideband RF systems. The wide variety of possible usages for such systems include countermeasures, electronic intelligence gathering, and target detection and identification. In these systems, one of the key elements is the antenna which allows the energy to be radiated and collects the return signal. Various approaches [1] including cavity backed spirals, sinuous antennas, and ridged horns have been considered to achieve broad bandwidth. This paper describes a novel technique for designing an ultra wideband antenna by proposing a new TEM-type feed.

Design Considerations

Fig. 1 shows the configuration of the ultra wideband antenna. The hybrid structure is comprised of a parabolic reflector, four linear struts, and a TEM feed. The struts, which are placed orthogonal to each other to form two pairs of balanced transmission lines, carry the energy from the antenna tip to the reflector. Since the balanced line is basically a set of two-conductor systems, appropriate spacing must be arranged in order to optimize the impedance matching. To allow the energy transfer from the signal source to the antenna tip, one of the arms is flush-mounted with the TEM feed line. Note that the transmission lines are directly connected to the reflector rim, and the tip is located at the reflector focal point. At the strut junctions, curved bends are also provided to minimize the discontinuities. The two primary factors determining the radiation characteristics are the reflector F/D ratio and flare angle δ. In the far-zone, the electric field may be obtained via the following relation

$$E_\theta = -j \frac{\omega\mu}{4\pi r} e^{-jkr} \iint_s \hat{a}_\theta \bullet J_s e^{jkr' \bullet \hat{a}_r} ds' + E_\theta^d \tag{1a}$$

$$E_\phi = -j \frac{\omega\mu}{4\pi r} e^{-jkr} \iint_s \hat{a}_\phi \bullet J_s e^{jkr' \bullet \hat{a}_r} ds' + E_\phi^d \tag{1b}$$

with J_s being the induced surface current density [2] and $E_{\theta,\phi}{}^d$ the components of the direct radiated field.

Experimental Data

In the actual prototype, the struts are made out of WR-10 copper waveguides and are 15.5 inches long, and the parabolic reflector has a F/D ratio of 0.375 with D equal to 30.0 inches. The TEM feed line and one of the struts were mated together by applying a silver tape. Measurements of the antenna radiation patterns were taken using an outdoor range. Figs. 2 to 5 show the radiation patterns of the hybrid orthogonal TEM fed reflector antenna measured at 0.5 GHz, 1.0 GHz, 2.0 GHz, and 5.0 GHz. Two different patterns were measured at each frequency with (a) in the elevation plane and (b) in the azimuth plane. At the frequency of 0.5 GHz, the 3-dB beamwidth in the elevation plane is 51.0° while in the azimuth plane the beamwidth is 130.0°. In general, as the operating frequency increases, the beamwidth of the principle patterns decreases. The half-power beamwidths are 7.0° and 5.0° at 5.0 GHz. The cross-polarized patterns were also measured, and they were at least 20.0 dB lower for the principle lobes. Note that the polarization of the hybrid TEM fed antenna is vertical.

The antenna has a boresight gain of 7.3 dBi, 11.6 dBi, 14.4 dBi, and 20.2 dBi at frequencies 0.5 GHz, 1.0 GHz, 2.0 GHz, and 5.0 GHz respectively. At each frequency, the gain was measured relative to a standard gain horn antenna.

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Conclusions

An experimental reflector antenna utilizing a hybrid orthogonal TEM feed concept is described. The new TEM feeding arrangement extends the operating frequency bandwidth by allowing the reflector antenna to operate efficiently at lower frequencies. The radiation characteristics were examined over a 10:1 bandwidth. The design is straightforward to implement, and it has great potential for high-power applications since the antenna structure can be completely fabricated from metal, without the need for loads or terminations.

References

[1] V. Rumsey, *Frequency Independent Antennas*, Academic Press, New York, 1966.
[2] C. Balanis, *Antenna Theory*, John Wiley & Sons Inc., 1982, pp. 619-623.

Acknowledgement

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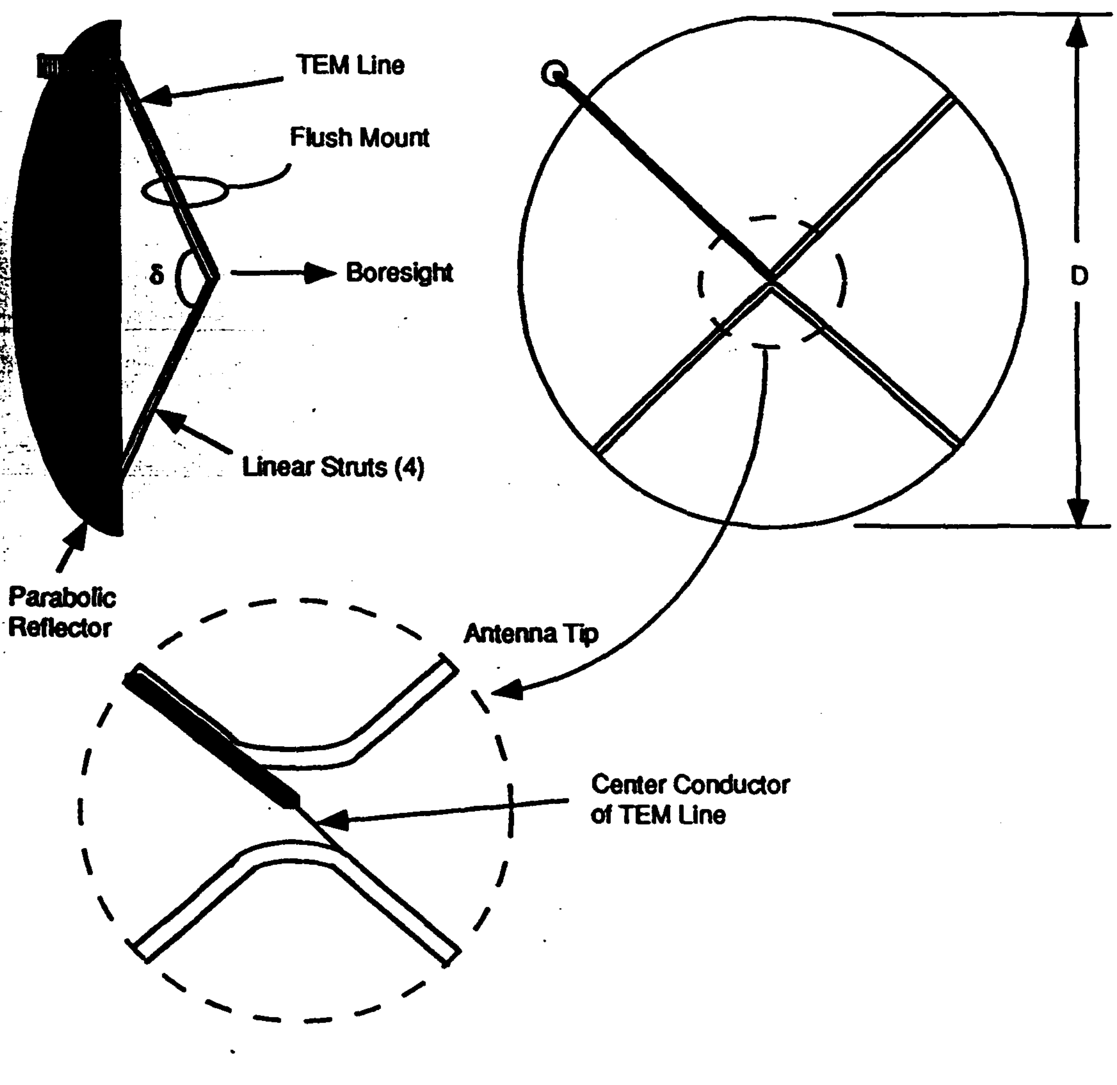
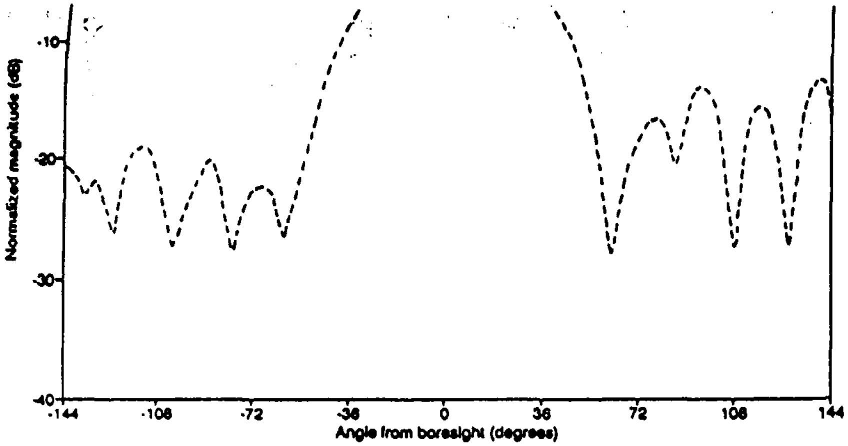


Fig. 1. Configuration of the hybrid orthogonal TEM feed reflector antenna

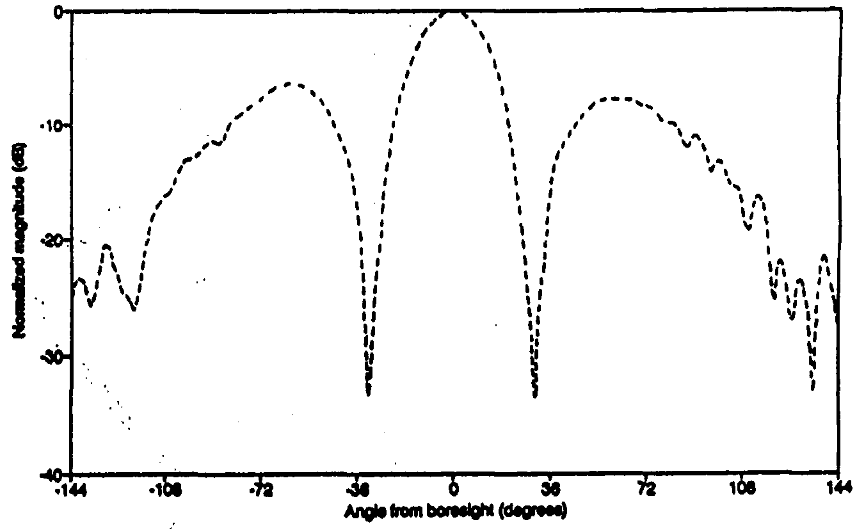


(a)

(b)

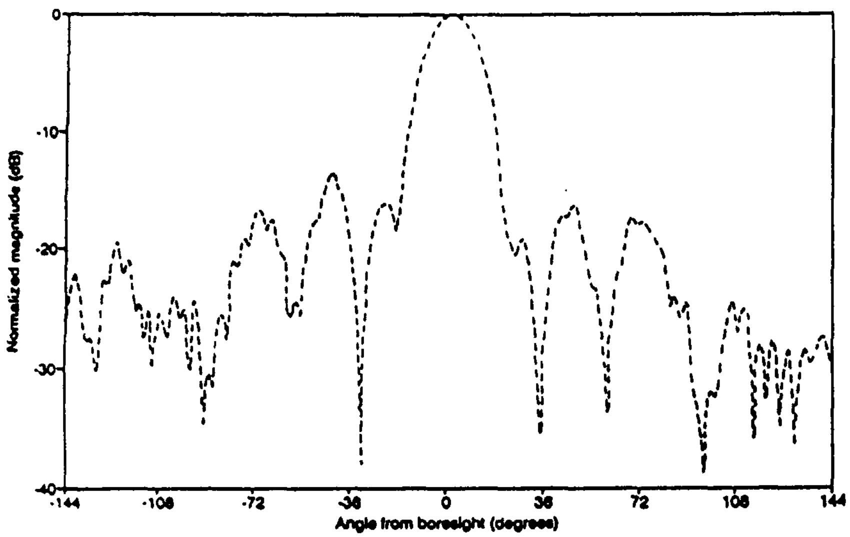
Fig. 2. Radiation patterns of the antenna at 0.5 GHz
(a) Elevation (b) Azimuth

(a)



(b)

Fig. 3. Radiation patterns of the antenna at 1.0 GHz
(a) Elevation (b) Azimuth



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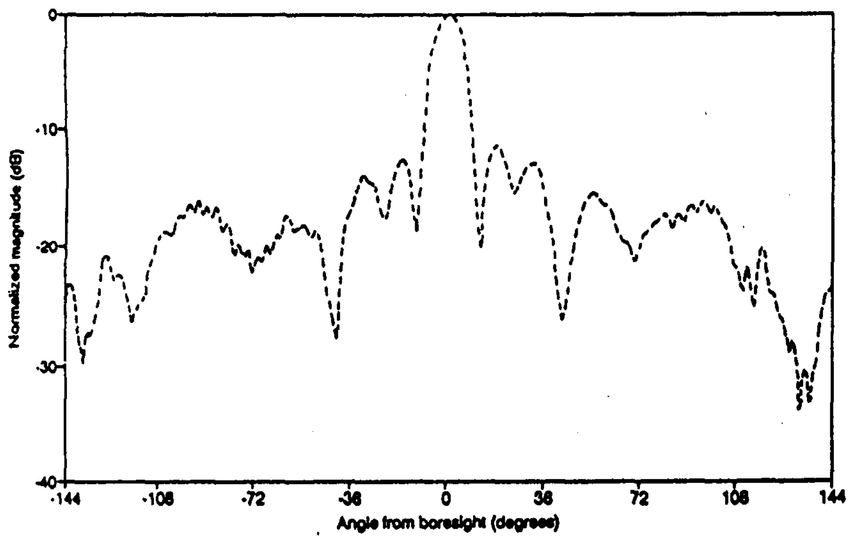
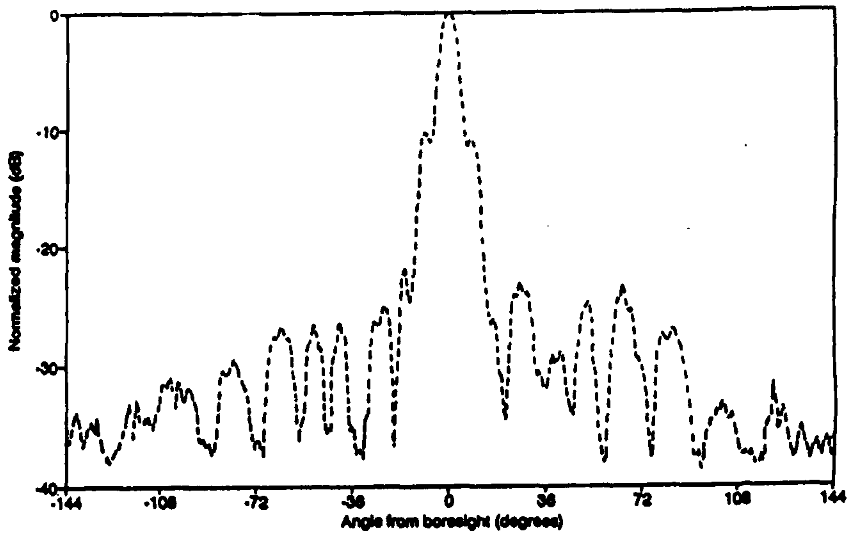
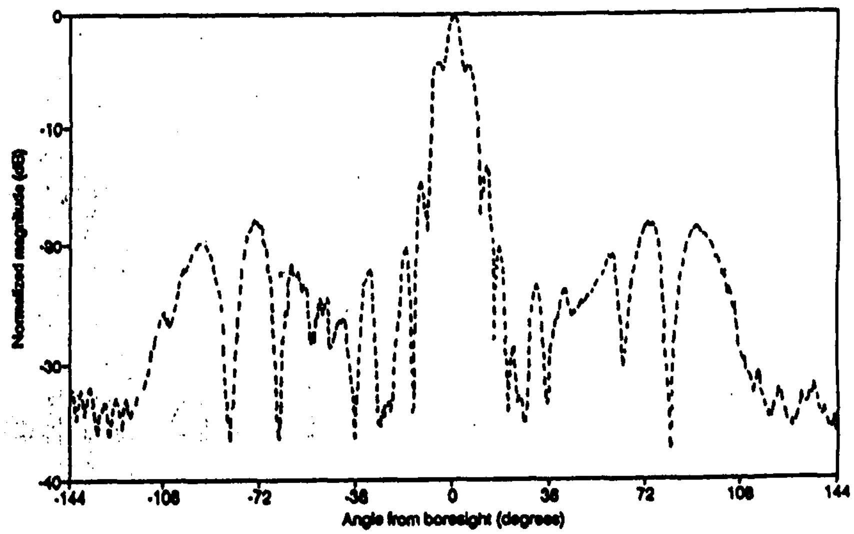


(b)

Fig. 4. Radiation patterns of the antenna at 2.0 GHz
(a) Elevation (b) Azimuth



(a)



(b)

Fig. 5. Radiation patterns of the antenna at 5.0 GHz
(a) Elevation (b) Azimuth